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Indian Standard

METHODS OF MEASUREMENTS ON GEIGER-MÜLLER COUNTER TUBES

UDC 621·387·424 : 621·317

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 1

Pri[redacted] Gr. 5 *September* 1968

Indian Standard

METHODS OF MEASUREMENTS ON GEIGER-MÜLLER COUNTER TUBES

Electron Tubes and Valves Sectional Committee, ETDC 39

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Indian Standard
METHODS OF MEASUREMENTS ON GEIGER-MÜLLER COUNTER TUBES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 14 June 1968, after the draft finalized by the Electron Tubes and Valves Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard deals with the methods of measurements on Geiger-Müller counter tubes and closely follows the IEC Doc : 39 (Secretariat) 168 Secretariat's proposal for methods of measurements of Geiger-Müller counter tubes.

0.3 This standard is one of a series of Indian Standards on electron tubes and valves for electronic equipment. A list of standards so far published in this series is given on fourth cover page.

0.4 In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2 - 1960*.

1. SCOPE

1.1 This standard covers the methods of measurements on Geiger-Müller counter tubes.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Counter Tube (Gas Ionisation Counter or Counter Tube) — A device in which ionisation is produced in a gas by individual particles or photons, thus enabling them to be counted.

*Rules for rounding off numerical values (*revised*).

2.2 Pulse — A brief change in current or voltage, such as results from the passage of an ionising particle (or two or more simultaneous ones) through a counter tube. A spurious pulse (interference pulse) is caused by an electrical or other disturbance.

2.3 Count

a) A pulse that has been registered, corresponding either to an ionising event or to an electrical disturbance (spurious count).

b) The number of pulses recorded in a specified period.

2.4 Counting (Count) Rate — The number of count per unit time.

2.5 Background of a Counter Tube — The counting rate in the absence of radiation which the counter tube is meant to measure.

2.6 Spurious Counts — Counts caused by an event other than the passage into or through a counter tube of the ionising radiations to which it is sensitive (*see also* **2.2**).

2.7 Avalanche — All the ions produced from a single primary ion through the process of cumulative ionisation.

2.8 Gas Multiplication (Amplification) — The process whereby in a sufficiently strong electric field the ions produced in a gas by ionising radiation produce additional ions.

2.8.1 *Gas Multiplication Factor* — The factor by which the initial ionisation is multiplied as a result of the gas multiplication process.

2.9 Proportional Region — The range of applied voltage in which the charge collected per isolated count is proportional to the charge liberated by the initial ionising event.

NOTE — In this region the gas multiplication (amplification) is greater than unity and is independent of the charge liberated by the initial ionising agent.

2.10 Region of Limited Proportionality — The range of applied voltages for a counter tube, below the Geiger-Müller threshold, over which the gas multiplication depends upon the number of ions produced in the initial ionising event as well as on the voltage.

2.11 Geiger-Region — In a Geiger-Müller counter tube, the range of applied voltages over which the charge collected per isolated count is independent of the number of primary ions produced in the initial ionising event and which results in a single (self-terminated) discharge.

2.12 Geiger-Müller Counter Tube — A gasfilled chamber, usually consisting of a hollow cylindrical cathode with a wire anode along its axis, which is operated in the Geiger-region and in which each ionising event is followed by only one terminated discharge.

2.13 Quenching — The act of terminating a pulse of ionisation current in a Geiger-Müller counter tube. This may be effected internally (internal or self-quenching) by the use, for example, of an appropriate gas or vopour filling, or externally (external quenching) by momentary reduction of the applied potential difference between the counter tube electrodes.

2.14 Self-Quenched Counter Tube — A Geiger-Müller counter tube in which the discharge is quenched by means of a suitable constituent in the counting gas.

2.15 Organic-Vapour Quenched Counter Tube — A self-quenched Geiger-Müller counter tube in which the quenching agent is an organic vapour as a constituent of counting gas.

2.16 Halogen Quenched Counter Tube — A self-quenched Geiger-Müller counter tube in which the quenching agent is a halogen usually bromine or chlorine.

2.17 Dead Time — The time interval, after the initiation of a normal size pulse, during which a counter tube is insensitive to further ionising events (*see also* **2.21**).

2.18 Resolution (Resolving) Time — Of a counter tube or counting system, the minimum time interval between two distinct events which will permit both to be counted as separate events.

2.19 Dead Time Correction — A correction to be observed counting rate based on the probability of the occurrence of events during the dead time of the Geiger-Müller counting tube.

2.20 Resolution Time Correction — Correction of the observed counting rate to allow for the occurrence of events within the resolution time of the system.

2.21 Recovery Time — Of a Geiger-Müller counter; the minimum time interval after the initiation of a normal size pulse before the next pulse of normal size.

2.22 Starting Voltage — The lowest voltage applied to a counter tube at which pulses can be detected by a system of stated characteristics (*see* Fig. 1).

2.23 Plateau Threshold Voltage — The applied voltage which corresponds to the start of the plateau for a stated sensitivity of the measuring circuit (*see* Fig. 1).

2.24 Plateau (of a Geiger-Müller Counter Tube) — The portion of the counting rate *versus* voltage characteristic in which the counting rate is substantially independent of the applied voltage and initial ionisation (*see* Fig. 1).

2.25 Plateau Length — The range of applied voltage over which the plateau extends.

2.26 Plateau Slope — The percentage change in count rate per volt for a given change usually 100 V in the applied voltage.

2.27 Sensitive Volume — That volume within a counter tube in which an ionising event produces an output pulse.

2.28 Radiation Sensitivity (Gamma and X-ray) — The counting rate for a given exposure (dose) rate produced by radiation of a stated energy.

2.29 Efficiency (of a Counter Tube) — For a stated radiation, the fraction that is counted of all the particles that enter the sensitive volume of the counter tube when the counting rate is low enough for the counting losses to be insignificant.

2.30 Window (of a Counter Tube) — That portion of the wall of a counter tube which is designed to allow the entry of the required radiation.

2.31 End Window Counter Tube — A counter tube designed for the radiation to enter at one end. It is usually a thin window counter tube, sometimes called a bell shaped counter tube.

2.32 Thin Wall Counter Tube — A counter tube in which the part of the envelope is designed to allow the entry of the required radiation.

2.33 Geiger-Müller Needle Counter Tube — A Geiger-Müller counter tube in which the sensitive volume is of small diameter, usually 2 to 3 mm, used in surgery.

2.34 Gas Sample Counter Tube — A counter tube into which the sample is introduced in the form of a gas.

2.35 Flow Counter Tube

2.35.1 *Gas Flow Counter Tube* — A counter tube in which an appropriate counting mixture is maintained in the counting tube by allowing a mixture to flow slowly through the volume.

2.35.2 *Liquid Flow Counter Tube* — A counter tube specially constructed for measuring the radioactivity of a flowing liquid.

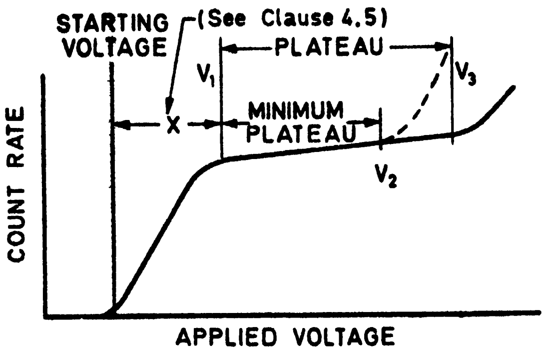
2.36 Liquid Sample Counter Tube — A counter tube suitable for the assay of liquid samples. It often consists of a thin glass walled Geiger-Müller counter tube with a surrounding glass jacket tube, providing an annular space for the sample.

3. BASIC THEORY

3.1 General Considerations — The characteristics of a Geiger-Müller counter tube are primarily defined by its plateau which is specified in terms of the plateau threshold voltage, plateau length and plateau slope (*see* Fig. 1). For the purpose of this standard, internally quenched Geiger-Müller counter tubes may be divided into two classes, namely:

a) organic-vapour quenched, and

b) halogen quenched.



V_1 = PLATEAU THRESHOLD VOLTAGE

FIG. 1 TYPICAL G.M. COUNTER TUBE CHARACTERISTIC UNDER CONSTANT IRRADIATION

3.1.1 The organic-vapour quenched counter tube requires a very high electric field to produce an electron avalanche. For this reason, the counter anode is in the form of a thin wire and the resulting steep potential gradient near the wire produces a current of short duration, followed by a 'tail' of small amplitude. The shape of the current pulse is unaffected by the external circuits being controlled entirely by the internal geometry and the applied voltage.

3.1.2 In most halogen quenched counter tubes, the electron avalanche is able to develop at relatively low field strengths and it is usual for the anode to be of larger diameter. The more diffuse space charge which thus occurs gives the counter tube some of the characteristics of a glow discharge device. Unlike the organic-vapour quenched tube the total charge generated at each counting event may be greatly influenced by the external circuit and the fraction of the charge contained in the long 'tail' of the pulse may be as high as 8 percent.

3.1.3 Typical current pulses are shown in Fig. 2 and 3. Figure 4 shows the circuit in which these current pulses may be observed. In both classes of counter tube, the charge generated per counting event will be a function of applied voltage and at any voltage the number of recorded events may be influenced by the input parameters of the measuring circuit. It is therefore necessary to specify the measuring circuit as accurately as possible to avoid differences in the measured results.

3.2 Choice of Basic Measuring Circuit Parameters

3.2.1 For any type of counter tube the basic measuring circuit may be represented as in Fig. 5.

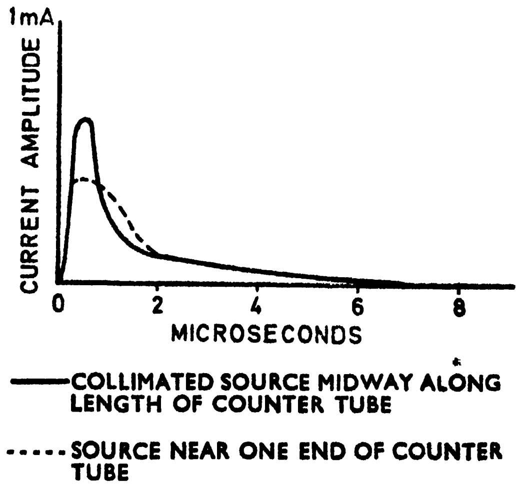


FIG. 2 TYPICAL CURRENT PULSE FROM ORGANIC-VAPOUR QUENCHED G.M. COUNTER TUBE

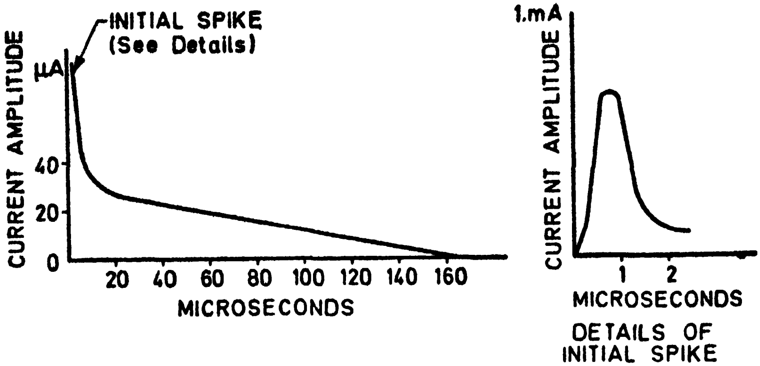
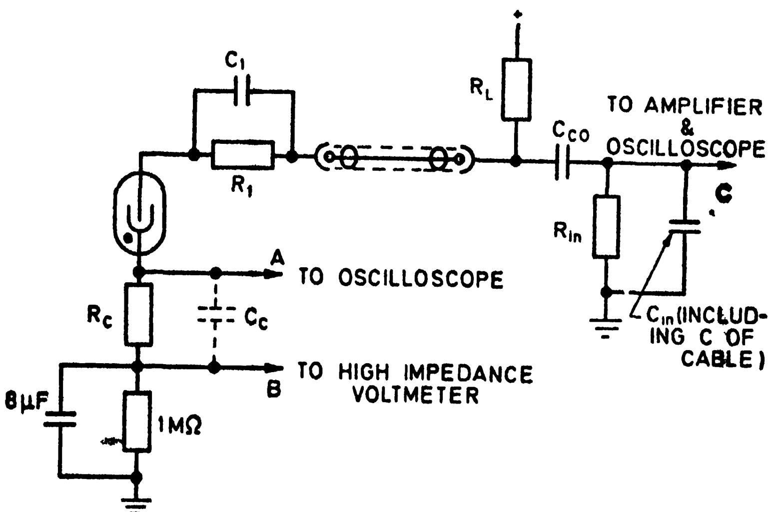


FIG. 3 TYPICAL CURRENT PULSE FROM HALOGEN QUENCHED G.M. COUNTER TUBE



NOTE — The product $R_c \cdot C_c$ should be negligible compared to the rise time of the current pulse.

OBSERVE AT:

A For current pulse; dead time

B For average charge per counting event

C For voltage pulse (effective charge per counting event)

FIG. 4 CIRCUIT FOR EXAMINATION OF THE CURRENT PULSE AND CHARGE PER COUNTING EVENT

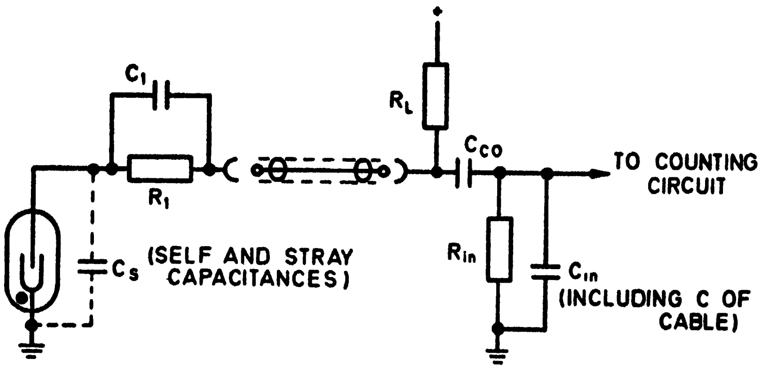
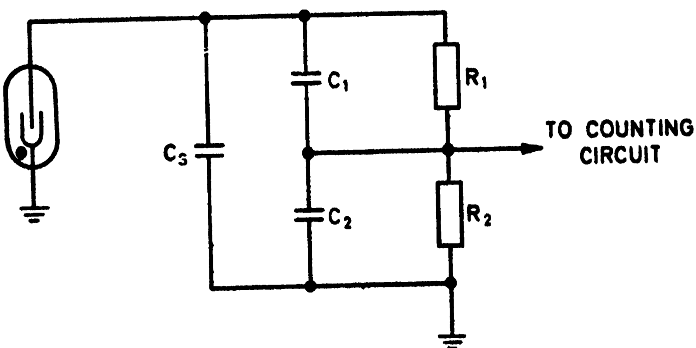


FIG. 5 BASIC MEASURING CIRCUIT FOR G.M. COUNTER TUBES

3.2.2 Components C_1 and R_1 are required with halogen quenched counter tubes in order to define an acceptable load having little effect on the performance of the tube, but are not necessary with organic-vapour quenched counter tubes. The capacitors indicated may be due to stray capacitances (which should be kept to a minimum) or actual components, and the resistors of any value. The coupling capacitor, C_{co} can be as large as desired and hence may be neglected when discussing an equivalent circuit. Figure 5 may then be redrawn as in Fig. 6.



$$C_2 = C_{in} \quad (\text{with } C \text{ of Cable})$$

$$R_2 = \frac{R_L \cdot R_{in}}{R_L + R_{in}}$$

FIG. 6 EQUIVALENT MEASURING CIRCUIT

3.2.2.1 Component C_1 should be made small enough so that (C_1+C_s) is a negligible load on the tube, but should be sufficiently large compared with C_s to give good transfer of charge to the counting circuit. C_s may be 1 to 2 pF or more (in some cases as high as 5 to 10 pF depending on counter tube construction). C_1 should be within the range 1 to 10 pF and its optimum value may be recommended by the manufacturer.

3.2.2.2 Component R_1 is usually in the range 2·7 to 10 M Ω and its value should be stated by the manufacturer. C_2 should be large compared with C_1 to minimize variations in the effective shunt capacity given by C_1 and C_2 in series, resulting from changes in cable length, and a value $C_2 = 100$ pF is recommended. It is convenient to make the input time constant C_2R_2 small, provided that it is sufficiently long to integrate most of the charge contained in the initial currrent 'spike', and a value of 3 micro-seconds is recommended, making R_2 about 33 K Ω R_{in} can be of the same order as R_2, with R_L greater than $10 \times R_{in}$.

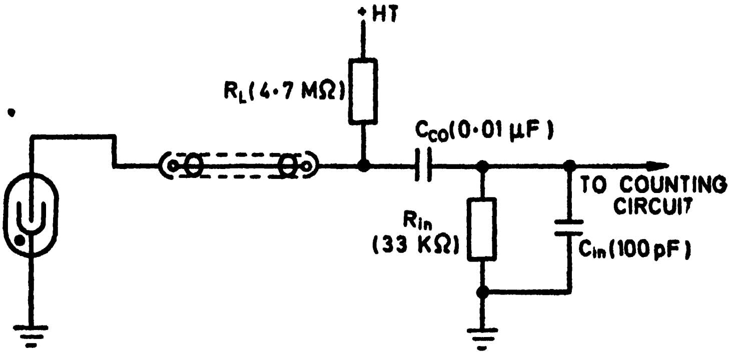
3.2.2.3 Taking typical values (of the majority of the counter tube types) for the average charge per pulse of organic-vapour and halogen quenched counter tubes, as 4×10^{-10} and 8×10^{-9} coulombs respectively at their recommended working voltages, and the effective charge per pulse (with an input time constant of 3 micro-seconds) as equal to 5×10^{-11} and approximately equal to 2×10^{-11} coulombs respectively at their starting voltages, the recommended counter circuit input sensitivity with $C_2 = 100$ pF, is 0·2 volt for organic-vapour quenched and 0·5 volt for halogen quenched counter tubes.

4. METHODS OF MEASUREMENT

4.1 Measuring Circuits

4.1.1 The factors governing the choice of the input parameters of the measuring circuits are given in **3.2** and recommended circuits for each class of counter tubes are given in Fig. 7 and 8. The component values given in these circuits should be suitable for most commonly used counter tubes, but alternative values may need to be selected if the characteristics of a particular counter tube differ widely from those assumed. If other values are chosen, the arguments set out in **3.1** and **3.2** should be considered.

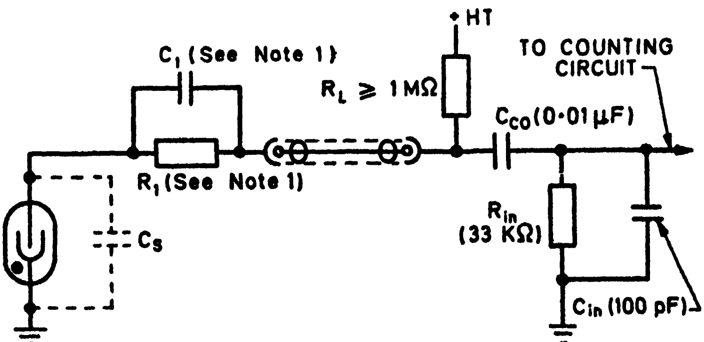
4.1.2 It is important to note that the counting circuit shall not generate any wave-form within itself which could be applied to the Geiger-Müller counter tube, or have a resolution time greater than the dead time of the counter tube being measured.



NOTE 1 — The input resistance and input capacitance of the counting circuit are incorporated in R_{in} and C_{in} together with the shunt capacitance of the cable.

NOTE 2 — Recommended input differentiating time constant,
$R_{in}\ C_{in} = 3\ \mu S$ with $C_{in} = 100$ pF (min)

FIG. 7 RECOMMENDED MEASURING CIRCUIT FOR ORGANIC VAPOUR QUENCHED COUNTER TUBES



NOTE 1 — C_1 and R_1 should be mounted close to the counter tube anode connector. The value of R_1 should be stated by the manufacturer (usually within the range 2·7 M Ω to 10 M Ω). The value of C_1 should be within the range 1 to 10 pF.

NOTE 2 — The input resistance and input capacitance of the counting circuit are incorporated in R_{in} and C_{in}, together with the shunt capacitance of the cable.

NOTE 3 — Recommended input differentiating time constant,
$R_{in}\ C_{in} = 3\ \mu s$ with $C_{in} = 100$ pF (min).

FIG. 8 RECOMMENDED MEASURING CIRCUIT FOR HALOGEN QUENCHED COUNTER TUBES

4.2 Ambient Conditions

4.2.1 Unless otherwise stated, the measurements are carried out in the temperature range 15° to 35°C.

4.2.2 Unless otherwise stated, the counter tube is exposed to a radiation of such a level that a count rate of approximately 100 counts per second is recorded when the tube is operated at its recommended working voltage. The radiation field should be uniform.

4.3 Statistical Variations — Some of the measurements described in this standard are subject to statistical variations. When the results of a measurement are quoted, these should be accompanied by a statement of the estimated standard deviation, or of the confidence level associated with that result.

4.4 Starting Voltage

4.4.1 The counter tube is operated with the appropriate measuring circuit (*see* Fig. 7 and 8), and in a radiation field as described in **4.2.2**. The output of this circuit is connected to an amplifier and an oscilloscope or scaler, adjusted to record pulses of a given minimum amplitude at the amplifier input (unless otherwise stated 0·2 volt for organic-vapour quenched and 0·5 volt for halogen quenched counter tubes are recommended).

4.4.2 The supply voltage is increased slowly from a low value until, at the starting voltage, the counting rate reaches about one count per second.

4.4.3 Starting voltage is normally read to the nearest 5·0 volt and is corrected to 27°C.

4.5 Plateau Threshold Voltage — The counter tube is operated (as in **4.4**) with appropriate measuring circuit (*see* Fig. 7 and 8) and in a radiation field as described in **4.2.2** and the supply voltage is increased in steps from the value corresponding to the starting voltage until the plateau is reached that is the counting rate is substantially constant. The number of counts is recorded at each voltage interval (say every 10 volts) over a sufficient period of time (for example, 1 minute), to reduce random variations to a suitable level. The results are plotted graphically and the voltage corresponding to the threshold of the plateau is recorded. Alternatively, the threshold voltage may be stated by the manufacturer as being:

Plateau threshold voltage = Starting voltage + X volts,

the value of X being given for each counter tube type (*see* Fig. 1).

4.6 Plateau Length and Plateau Slope — The counter tube is operated in the appropriate measuring circuit (*see* Fig. 7 and 8), and in a radiation field as described in **4.2.2**. The number of counts is recorded over a sufficient period of time (for example, 1 minute), to reduce random variations to a suitable level at each end of the minimum plateau (V_1 and V_2).

Normally a minimum plateau length will be stated by the manufacturer, with limits defined by V_1 and V_2 in Fig. 1. The plateau slope is calculated over the minimum plateau length and if the number of counts recorded (for the same period of time) at V_1 and V_2 is N_1 and N_2 respectively, the plateau slope is given by:

$$\frac{N_2-N_1}{\frac{1}{2}(N_2+N_1)} \times \frac{100}{(V_2-V_1)} \text{ percent per volt.}$$

4.7 Recommended Working Voltage — The recommended working voltage should be taken as the middle of the minimum plateau $\left(\text{that is } \frac{V_1+V_2}{2}\right)$ (*see* **4.6**).

NOTE — Usually this voltage is recommended by the manufacturer.

4.8 Shielded Background Count Rate — The counter tube is operated with appropriate measuring circuit (*see* Fig. 7 and 8) and at the recommended voltage. Sources of radiation are removed and the tube is shielded by at least 3·5 mm of lead, with an inner liner of 3·2 mm of aluminium.

For tubes intended for special applications, other forms of shielding may be used and this should be specified.

The count rate is determined over a sufficient period of time to reduce random variations to a suitable level.

4.9 Average Electrical Charge per Counting Event — The counter tube is operated with appropriate measuring circuit (*see also* Fig. 4) with the recommended working voltage, and is exposed to radiation as described in **4.2.2**.

The average current drawn by the counter tube is measured simultaneously with the measurement of count rate (*see* **4.8**). The average electrical charge per counting event is then given by:

$$\text{Average charge per counting event} = \frac{\text{average current}}{\text{count rate}}.$$

4.10 Pulse Height (Effective Electrical Charge per Counting Event)—The counter tube is operated in the appropriate measuring circuit (*see* Fig. 4) with the recommended working voltage applied, and is exposed to radiation as described in **4.2.2**. An oscilloscope, or other suitable pulse height measuring apparatus, is connected to the output terminals in accordance with **3.1** and **4.1**. The effective charge per counting event is expressed as the peak voltage charge across the stated input capacitor and resistor.

4.11 Dead Time and Recovery Time—Two methods (Method A and Method B) are specified.

4.11.1 *Method A*—The counter tube is operated at its recommended working voltage, with the appropriate measuring circuit (*see also* Fig. 4), and the output of this circuit (point *A*) is connected to the *Y*-plate input of an oscilloscope. The time base of the oscilloscope is set to trigger only on pulses of approximately full amplitude, and the time base set so that the time to traverse the *X*-axis is just greater than the recovery time of the counter tube. The counting tube is operated at a high counting rate (for example, 500 pulses per second) resulting in an oscilloscope display from which both dead time and recovery time can be estimated. Typical examples are shown in Fig. 9 and 10.

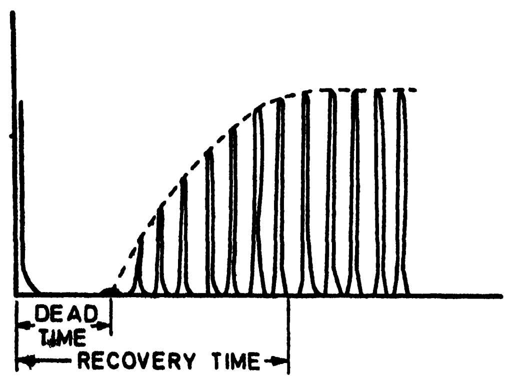


FIG. 9 TYPICAL OSCILLOGRAPH SHOWING DEAD TIME AND RECOVERY TIME OF ORGANIC-VAPOUR QUENCHED COUNTER TUBE

4.11.2 *Method B*—An alternative method for measuring the dead time is to use a doubly pulsed X-ray apparatus, wherein the relative time delay between the two X-ray pulses can be adjusted.

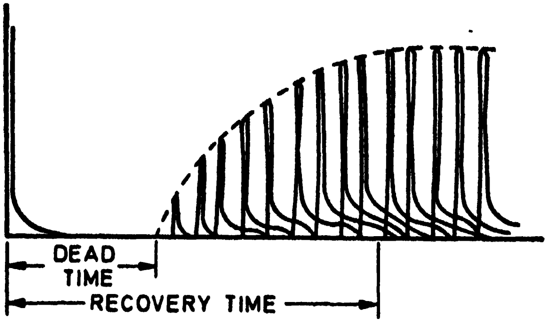


FIG. 10 TYPICAL OSCILLOGRAPH SHOWING DEAD TIME AND RECOVERY TIME OF HALOGEN QUENCHED COUNTER TUBE

The Geiger-Müller tube is operated at its recommended working voltage in the appropriate measuring circuit (*see also* Fig. 4) and the output of this circuit is connected to the *Y*-plate input of an oscilloscope, the time base of the oscilloscope is triggered on the first pulse of the counter tube. The time delay between the two X-ray pulses is decreased to the minimum value at which the counter tube still reacts to the second X-ray pulse. The dead time is this minimum value of the time delay between the two pulses and can be read from the oscilloscope.

4.12 Radiation Sensitivity (Gamma and X-ray)

4.12.1 The counter tube is positioned so as to receive the minimum stray and scattered radiation from surrounding objects and is operated in the appropriate measuring circuit with the recommended working voltage applied. A suitable source of gamma or X-radiation (*see* Note 1) is placed either side on or end on (*see* Note 2) to the tube at such a distance that the tube is in a sensibly uniform radiation field.

If the wall thickness of the counter tube is less than that required for electronic (charged particle) equilibrium at the particular radiation energy used, a close fitting plastic build-up cap should be fitted over the counter tube to give the appropriate total wall thickness (*see* Note 3).

The strength of the source and the distance shall be so chosen that the tube counting rate is high enough to permit reasonably rapid measurements of sufficient statistical accuracy, and yet not so high as to lead to appreciable dead time losses.

The tube counting rate is determined by recording the number of counts over a sufficient period of time to reduce random variations to an acceptable level. The net tube counting rate is obtained by subtracting the background count rate from the measured tube count rate.

NOTE 1 — Radiation from gamma sources should be filtered to remove beta radiation and unwanted soft gamma components. Whenever the gamma dose-rate is appreciably altered by the filter the nature and thickness of the filter should be specified.

For Co^{60} the minimum filter should be 0·3 mm Al. Unless otherwise stated, it will be assumed that radioactive materials are in equilibrium with their daughter products (if any).

Radiation from X-ray tube should also be filtered. The filtration and/or the H.V.T. (half valve thickness) of the filtered beam should be specified.

NOTE 2 — The side-on position will normally be used for gamma sensitivity measurements.

A statement about directional dependence (if any) of response should be made.

For measuring the sensitivity of end-window tubes to softer radiation, the end-on position should be used.

NOTE 3 — To achieve electronic equilibrium for Co^{60} radiation, the counter tube wall should have a minimum wall thickness of about 400 mg/cm². If the wall thickness is less than 400 mg/cm², a plastic build-up fitted to bring the effective wall thickness up to 400 mg/cm².

4.12.2 The dose-rate to which the counter tube is exposed is determined either by replacing the tube with a suitable dose-rate meter, or (in the case of a radioactive source) from a knowledge of the source strength and distance (*see* Note).

NOTE — The dose-rate by a point source of gamma radiation is given by:

$$\text{Dose-rate in mr/h} = \frac{\tau}{d^2} \times \text{source strength in millicuries,}$$

where τ is a constant for the radioactive material used and d is the distance in centimetres. (for Co^{60} : $\tau = 13{\cdot}2 \times 10^3$)

4.12.3 The sensitivity is then the quotient of the net tube count rate and the dose-rate, and is expressed in counts/Rontgen or more usually in counts per second per milli-Rontgen per hour.

It should be noted that the sensitivity is likely to vary with the energy of the radiation. When an energy response curve is not given, the radiation source should therefore be specified. It is recommended that the sensitivity should be given for Co^{60} (*see* Note 1 under **4.12.1**).

4.13 Temperature Coefficient of Starting Voltages and Plateau Threshold Voltage — The starting voltage is measured at two different temperatures which are chosen to be near the ends of the operating temperature range. If the starting voltages are V_{s1} and V_{s2} at temperatures

T_1 and T_2 respectively, and the temperature coefficient is linear over the operating temperature range, then temperature coefficient is given by:

$$\frac{V_{S2}-V_{S1}}{\frac{1}{2}(V_{S2}+V_{S1})} \times \frac{100}{T_2-T_1} \text{ percent per deg C.}$$

Since the difference between the threshold voltage and the starting voltage is approximately constant, the temperature coefficient of the starting voltage will also be the temperature coefficient of the threshold voltage.

If the relationship over the required operating range is essentially non-linear, then it may be necessary to define different coefficient over different temperature range, and the starting voltage should be measured at appropriate temperature intervals over the operating temperature range.

The results are plotted graphically and from this graph the variation of temperature coefficient over given temperature ranges can be calculated.

4.14 Temperature Coefficient of Radiation Sensitivity — Changes in radiation sensitivity (counting rate) resulting from temperature variations can normally be computed (with sufficient accuracy) from the plateau slope (*see* **4.6**) and the temperature coefficient of starting voltage (and plateau threshold voltage).

5. MECHANICAL DATA

5.1 Dimensions — The manufacturer should provide in his catalogue, drawings of the Geiger-Müller counter tube showing dimensions and tolerances, and indicating the position of the active part of the tube (for gamma-ray sensitive devices) or the position and area of the thin window (for alpha and beta-ray sensitive devices).

Indications should also be given of the means of mounting and the position of electrical contacts, with their polarity (where appropriate).

5.2 Window or Wall Thickness — The manufacturer should provide information on the window or wall thickness, (as appropriate to the type of counter tube), quoted in mg/cm^2 and the material of which the window or wall is constructed.

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AMENDMENT NO. 1 OCTOBER 1969

TO

IS : 4697-1968 METHODS OF MEASUREMENTS ON GEIGER-MULLER COUNTER TUBES

Corrigenda

(*Page* 2, *composition of* ETDC 39 : P 6) — Substitute the following for the existing composition:

Panel for Special Purpose Tubes, ETDC 39 : P6

Convener	
SHRI G. H. VAZE	Bhabha Atomic Research Centre, Bombay
Member	
SHRI P. K. PATWARDHAN	Bhabha Atomic Research Centre, Bombay

(ETDC 39)

Printed at Neelkamal Printers, Delhi 6, India

AMENDMENT NO. 2 NOVEMBER 1973
TO
IS : 4697-1968 METHODS OF MEASUREMENTS ON GEIGER-MÜLLER COUNTER TUBES

Alterations

(*Page* 4, *clause* **2.2**) — Substitute the following for the existing clause

'**2.2 Pulse** — A brief change in current or voltage, such as results from the passage of an ionising particle or quanta (or two or more simultaneous ones) through a counter tube.

2.2.1 *Spurious Pulse* — A pulse generated without the passage of ionising par~~ticle or quanta.'~~

(*Page* 4, *clause* **2.3**) — Substitute the following for the existing clause:

'**2.3 Count** — The number of pulses recorded in a specified period.'

(*Page* 4, *clause* **2.5**, *clause heading*) — Substitute '**Background**' *for* '**Background of a Counter Tube**'.

(*Page* 4, *clause* **2.6**)

a) *Line* 1 — Substitute 'any event' for 'an event'.

b) *Line* 3 — Delete the words '(*see also* **2.2**)'.

(*Page* 4, *clause* **2.8.1**, *line* 2) — Substitute 'process under stated conditions' *for* 'process'.

(*Page* 4, *clause* **2.9**, *Note*, *line* 1) — Substitute 'gas multiplication factor' *for* 'gas multiplication (amplification)'.

(*Page* 5, *clause* **2.15**, *line* 3) — Delete the words 'as a constituent of counting gas'.

(*Page* 5, *clause* **2.19**, *line* 3) — Substitute 'counter' *for* 'counting'

(*Page* 5, *clause* **2.20**, *line* 2) — Substitute 'probability of the occurrence' *for* 'the occurrence'.

(*Page* 6, *clauses* **2.23** *and* **2.24**) — Transpose these clauses and re-number '**2.24**' as '**2.23**' and '**2.23**' as '**2.24**'.

(*Page* 6, *clause* **2.26**, *line* 2) — Substitute 'in the applied voltage (usually 100 V)' *for* 'usually 100 V in the applied voltage'.

[*Page* 6, *clause* **2.33** (*re-numbered* **2.35**), *clause heading*] — Substitute the following for the existing heading:

'**Needle Counter Tube**'

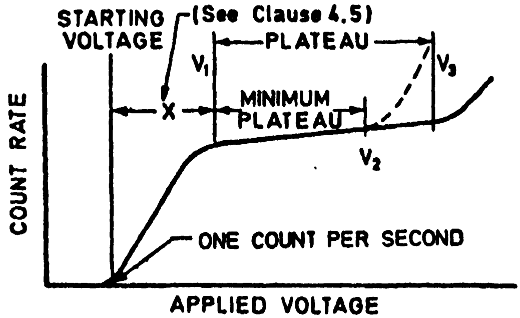
Price Re **1·00**

[*Page* 6, *clause* 2.34 (*re-numbered* 2.36)] — Substitute the following for the existing clause:

'**2.36 Gas Sample Counter Tube** — A counter tube in which the filling gas consists wholly or partly of the radioactive gas whose activity is to be measured.'

[*Page* 7, *clause* 2.36 (*re-numbered* 2.38), *line* 3] — Substitute 'sealed into or attached to a surrounding glass' *for* 'with a surrounding glass'.

(*Page* 7, *Fig.* 1) — Substitute the following for the existing figure:



V_1 — PLATEAU THRESHOLD VOLTAGE

FIG. 1 TYPICAL G. M. COUNTER TUBE CHARACTERISTIC UNDER CONSTANT IRRADIATION

(*Page* 7, *clause* 3.1.1, *line* 6) —Substitute 'and is being controlled' *for* 'being controlled'.

(*Page* 10, *clause* 3.2.2, *line* 8, *last sentence*) — To be a separate clause numbered as '3.2.3'.

(*Page* 11, *clause* 3.2.2.1) — Re-number as '3.2.3.1'.

(*Page* 11, *clause* 3.2.2.2)

a) Re-number as '3.2.3.2'.
b) *Line* 8 — Insert 'full stop' after '33 K/Ω'.

(*Page* 11, *clause* 3.2.2.3)

a) Re-number as '3.2.3.3'.
b) *Lines* 5 *and* 6 — Substitute 'as approximately equal to 2×10^{-11} and 5×10^{-11} coulombs' *for* 'as equal to 5×10^{-11} and approximately equal to 2×10^{-11} coulombs'.

(*Page* 13, *clause* **4.4.1**)

a) *Line* 1 — Substitute ' in ' *for* ' with '.

b) *Lines* 4 *and* 5 — Substitute ' across the counter tube ' *for* ' at the amplifier input '.

(*Page* 13, *clause* **4.5**, *line* 2) — Substitute ' in the ' *for* ' with '.

(*Page* 14, *clause* **4.6**, *line* 5) — Substitute ' V_3 ' *for* ' V_2 '.

(*Page* 14, *clause* **4.8**)

a) *Heading* — Delete the words ' **Count Rate** '.

b) *Line* 2 — Substitute ' in the ' *for* ' with '.

c) *Line* 4 — Substitute ' 35 mm ' *for* ' 3·5 mm '.

(*Page* 14, *clause* **4.9**, *line* 2) — Substitute ' in the ' *for* ' with '.

(*Page* 15, *clause* **4.10**)

a) *Line* 3 — Substitute ' Fig. 7 and 8 ' *for* ' Fig. 4 '.

b) *Lines* 6 *and* 7 — Substitute ' amplitude ' *for* ' effective charge per counting event '.

c) *Line* 7 — Substitute ' change ' *for* ' charge '.

(*Page* 15, *clause* **4.11.1**)

a) *Line* 2 — Substitute ' in ' *for* ' with ' and delete the word ' *also* '.

b) *Line* 7 — Substitute ' counter tube ' *for* ' counting tube '.

(*Pages* 15 *and* 16, *Fig.* 9 *and* 10) — Substitute the following for the existing figures:

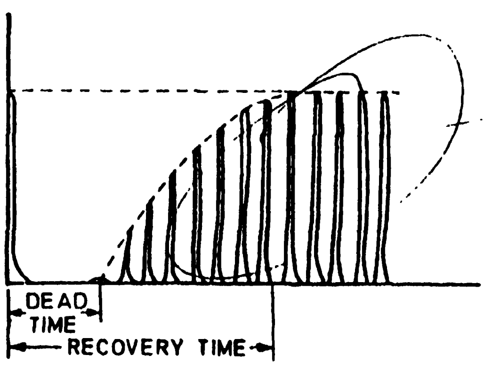


FIG. 9 TYPICAL OSCILLOGRAPH SHOWING DEAD TIME AND ~~RECOVERY~~ TIME OF ORGANIC-VAPOUR QUENCHED COUNTER TUBE

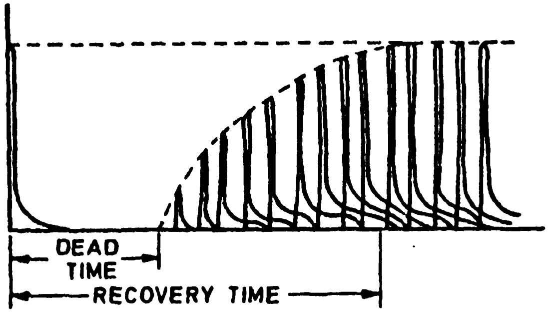


FIG. 10 TYPICAL OSCILLOGRAPH SHOWING DEAD TIME AND RECOVERY TIME OF HALOGEN QUENCHED COUNTER TUBE

(*Page* 16, *clause* **4.11.2**, *second para, line* 2) — Delete the word '*also*'.

(*Pages* 16 *and* 17, *clause* **4.12.1**, *fourth para*)

a) *Line* 2 — Delete the words 'period of'.

b) *Line* 3 — Substitute 'count' *for* 'counting'.

c) *Note* 1, *line* 2 — Substitute 'exposure-rate' *for* 'dose-rate'.

d) *Note* 1, *third para, line* 1 — Substitute 'tubes' *for* 'tube' and add the following new paragraph under this note:

'Precautions should be taken to avoid Compton effect due to the counter-tube-source geometry.'

e) *Note* 2, *second para* — Substitute 'is variable' *for* 'should be made'.

f) *Note* 3, *line* 3 — Substitute 'build-up cap should be' *for* 'build-up'.

(*Page* 17, *clause* **4.12.2**, *Note*) — Substitute the following for the existing note:

'NOTE — The exposure-rate by a point source of gamma radiation is given by:

$$\text{Exposure-rate in mr/h} = \frac{\tau}{d^2} \times \text{activity in millicuries}$$

where τ is a constant for the radioactive material used which is internationally accepted by the authorized organizations and d is the distance in centimetres (for Co^{60}: $\tau = 13{\cdot}2 \times 10^3$).'

(*Page* 17, *clause* **4.12.3**)

a) *Line* 2 — Substitute 'exposure-rate' *for* 'dose-rate' and delete the words 'counts/Rontgen or more usually in'.

b) *Second para, line* 3 — Delete the word 'therefore'.

(*Pages* 17 *and* 18, *clause* **4.13**) — Substitute the following for the existii clause:

'**4.13 Temperature Coefficient of Starting Voltage and Plateau Threshold Voltage** — If the relationship over the required operating range is non-linear, then it may be necessary to define different coefficients over different temperature ranges, and the starting voltage should be measured at appropriate temperature intervals over the operating temperature range.

The results are plotted graphically and from this graph the variation in temperature coefficient over given temperature ranges can be calculated.

If the temperature coefficient is linear over the operating temperature range, the starting voltage is measured at two different temperatures which are chosen to be near the ends of the operating temperature range.

If the starting voltages are V_{s1} and V_{s2} at temperatures T_1 and T_2 respectively, then the temperature coefficient is given by:

$$\frac{V_{s2} - V_{s1}}{\frac{1}{2}(V_{s2} + V_{s1})} \times \frac{100}{(T_2 - T_1)} \text{ percent per deg C.}$$

Since the difference between the threshold voltage and the starting voltage is approximately constant, the temperature coefficient of the starting voltage will also be the temperature coefficient of the threshold voltage.'

(*Page* 18, *clause* **4.14**) — Substitute the following for the existing clause:

'**4.14 Temperature Coefficient of Radiation Sensitivity** — If the relationship over the required operating range is non-linear, then it may be necessary to define different coefficients over temperature ranges, and the sensitivity should be measured at appropriate temperature intervals over the operating temperature range.

The results are plotted graphically and from this graph the variation in temperature coefficient over the given temperature range can be calculated.

If the temperature coefficient is linear over the operating temperature range, the sensitivity is measured at two different temperatures which are chosen to be near the ends of the operating temperature range.

If the sensitivities are S_1 and S_2 at temperatures T_1 and T_2 respectively, then the temperature coefficient is given by:

$$\frac{S_2 - S_1}{\frac{1}{2}(S_2 + S_1)} \cdot \frac{100}{T_2 - T_1} \text{ percent per deg C.'}$$

Addenda

(*Page* 6, *clause* 2.27) — Add the following new clause after 2.27 and re-number the subsequent clauses accordingly:

'**2.28 Useful Area** — Part of the window of a counter tube for which a particle or an incident quanta may be the origin of an output pulse.'

[*Page* 6, *clause* 2.29 (*re-numbered* 2.30), *line* 2] — Add 'or quanta' after 'particles'.

[*Page* 6, *clause* 2.29 (*re-numbered* 2.30)] — Add the following new clause after re-numbered 2.30 and re-number the subsequent clauses accordingly:

'**2.31 Detection Efficiency** — Ratio of the number of counts to the total number of particles or of quantas falling on the useful area, when the counting rate is sufficiently low to make a correction of dead time unnecessary.'

(*Page* 8, *clause* 3.1.2) — Add the following new clause after 3.1.2:

'**3.1.2.1** The discharge of the halogen quenched counter tube is strongly influenced by the impedance of the tube (resistance and capacitance). Moreover, the number of recorded counts is strongly influenced by the measuring equipment (input sensitivity, input impedance, and time constant).'

(*Page* 13, *clause* 4.2.2) — Add the following note under this clause:

'NOTE — When measuring counter tubes having a dead time greater than 500 µs (estimated at the recommended working voltage), the radiation field should be reduced so that the count rate is approximately

$$\frac{5 \times 10^4}{(\text{dead time in } \mu s)} \text{ counts per second'}$$

(*Page* 13, *clause* 4.4.3) — Add the following note under this clause:

'NOTE — The measurement value may depend upon the sensitivity threshold of the measuring circuit.'

(*Page* 14, *clause* 4.9) — Add the following note at the end of the second para:

'NOTE — The counting rate is expressed in counts per second.'

(ETDC 39)

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